Impact of 2011 Resident Duty Hour Requirements on Neurology Residency Programs and Departments

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Abstract

Objective: In 2011, the Accreditation Council on Graduate Medical Education (ACGME) redefined resident duty hour requirements by reducing in-hospital duty hour requirements for residents in an effort to improve patient care, resident well-being, and resident education. We sought to determine the cost of adoption based on changes made by neurology residency programs and departments due to these requirements. **Methods:** We surveyed department chairs or residency program directors at 123 ACGME-accredited US adult neurology training programs on programmatic changes and resident expansion, hiring practices, and development of new computer-based resources in direct response to the 2011 ACGME duty hour requirements. Using data from publicly available resources, we estimated respondents' financial cost of adoption. **Results:** In all, 63 responded (51% response rate); 76% were program directors. The most common changes implemented by programs were adding night float systems ($n = 31$; 49%) and increasing faculty responsibility ($n = 26$; 41%). In direct response to the requirements, 21 programs applied to ACGME for 40 additional residents, 29 of which were fully covered by institutional funds. In direct response to the requirements, nearly half of the departments ($n = 26$) hired individuals for a total of 80 hires (or 64 full-time equivalents), most commonly mid-level practitioners. The total estimated cost to responding departments was US \$12.7 million or US \$201,000 per department annually. When projecting expenses of planned changes for the following year, costs increased to US \$360,000 per department, with 5-year costs exceeding US \$1 million. **Conclusions:** The most recent restriction on resident duty hours comes at substantial cost to neurology departments and residency programs.

Keywords

education, training, academic, quality, safety, costs

Introduction

In 2011, the Accreditation Council on Graduate Medical Education (ACGME) redefined common programmatic duty hour requirements for all residents in training, including neurology (see Table 1).¹ This redefinition was in response to the recommendations of the Institute of Medicine, which previously concluded that resident fatigue makes errors more likely to occur and thus compromises patient care.² Effective July 1, 2011, these requirements included a refinement of the prior 2003 ACGME duty hour requirements for an 80-hour weekly work limit along with other prior changes.

The national and total programmatic costs of the 2011 requirements while maintaining current patient care productivity have been projected to range from \$180 to \$980 million,³ with concern that the total labor costs would be even higher.⁴ Anticipated issues related to their implementation include the influence of educational and logistical concerns on department hiring as well as varying financial implications

for hospitals and residency programs.³ Although previous studies estimate the financial burden on hospitals prior to implementation of changes, to the knowledge of the authors, there has been no retrospective evaluation of costs on the hospital or departmental level using primary data.

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Table 1. 2011 ACGME Programmatic Requirements: Restrictions on Duty Hours for PGY-2 and Above Residents.

- Duty periods may be scheduled to a maximum of 24 hours of continuous duty in the hospital with the encouragement of strategic napping after 16 hours of continuous duty.
- To assure effective transitions of patient care, residents are allowed to remain on-site to accomplish tasks related to patient care up to 4 hours after their maximum of 24 hours of continuous duty period.
- No additional clinical responsibilities may be assigned to a resident after 24 hours of continuous in-house duty.
- Residents should have 10 hours, but must have 8 hours, free of duty between scheduled duty periods as well as at least 14 hours free of duty between 24 hours of in-house duty.
- Residents must not be scheduled for more than 6 consecutive nights of night float duty.
- Residents must be scheduled for in-house call duty no more frequently than every third-night, averaged over a four-week period.

Abbreviations: ACGME, Accreditation Council on Graduate Medical Education; PGY-2, postgraduate year 2.

This study presents a national survey of department chairs and residency program directors of adult neurology training programs, designed to understand changes and costs of those changes at the residency program and department level in response to the most recent ACGME duty hour requirements.

Methods

Participants

We surveyed 123 neurology departments in the United States with an ACGME-accredited and active adult neurology residency training program in 2011.⁵ Military-based residency programs and programs within United States territories (e.g., Puerto Rico) were excluded. We identified neurology department chairs and residency program directors using publically available resources.⁶ Department chairs and program directors were surveyed as they were most likely to have knowledge of department and residency program responses to the new duty hour requirements, departmental hiring, and plans for the development of neurohospitalist training programs. We e-mailed a link to the electronic survey to department chairs, asking that they, their residency program directors, administrators, or other faculty within their department, complete the survey. If no response was received, the electronic survey was sent to residency program directors who were then asked to complete the survey. Reminder e-mails were sent and telephone calls were made to nonrespondents. Responses were collected between March 27 and June 27, 2012. The Johns Hopkins School of Medicine institutional review board approved the study.

Survey Instrument

The survey instrument was designed in collaboration with senior faculty from Johns Hopkins Department of Neurology and School of Public Health. Focus groups with residents and

neurology department leadership were held to validate the survey (supplementary appendix). The survey contained 13 questions related to neurology department and residency program changes in direct response to the July 2011 resident duty hour requirements¹ and 10 questions on hospital, department, program, and respondent characteristics (supplementary appendix). The survey was conducted simultaneously with queries regarding neurohospitalist training, the results of which have been published separately.⁷ Respondents were asked to choose from a multiple-choice list for many of the questions, some of which could accommodate multiple answers. Several questions utilized either a 4-point scale (never, occasionally, frequently, and always) or a 5-point Likert-type scale. To control for potential asymmetry in knowledge across respondents and to assure the collection of accurate information, we included the option to select “do not know” on some questions or opt out of a question altogether. Here we present findings regarding neurology department and residency program responses to the 2011 duty hour requirements.

Cost Estimation

Direct costs to responding neurology departments were estimated using assumptions from publicly available resources and the recent literature,^{3,8-14} department and program queries of computer-based resource development, department hires, and additional residents in direct response to the 2011 ACGME guidelines within the survey. Reported full-time equivalent (FTE) hires were used to estimate the work capacity for the number of substitute providers in the analysis. Since the number of hires for those departments planning to hire substitute providers was not obtained by survey, projections of planned changes for provider hires were estimated using data on department reports of implemented changes. Department plans to adopt computer-based resources and hire additional residents were taken directly from the survey. Assumptions on costs of hires and additional residents were made using publically available data on wages, stipends and benefits,⁸⁻¹³ and prior estimates of the direct cost of residency training.¹⁴ Assumptions on cost of computer resources were derived from the literature.³ Generally, base case assumptions are median values with the range of sensitivities representing the 25th to 75th percentiles for the lowest and highest case, respectively. Model inputs and outputs are presented in 2012 US dollars.¹⁵

Statistical Analysis

We used the Wilcoxon Mann-Whitney test to examine differences between respondents and nonrespondents in first-year class size as reported by the Fellowship and Residency Electronic Interactive Database Access (FREIDA) system and 2011 estimated metropolitan size from the US Census Bureau.⁵ Differences in program type (community based, community-based university affiliated, university affiliated)

Table 2. Residency Program and Neurology Department Response to 2011 Duty Hour Requirements.^a

	Number of Respondents, %			
	Yes, Implemented	Planning to Implement	No, Not Implementing	Do Not Know
Residency program internal response ^b				
Introduced night float	31 (49)	1 (2)	27 (43)	4 (6)
Increased faculty responsibility/coverage	26 (41)	8 (13)	29 (46)	0 (0)
Decreased elective blocks	15 (24)	6 (10)	41 (65)	1 (2)
Rescheduled educational activities	15 (24)	4 (6)	43 (68)	1 (2)
Developed computer-based resources	13 (21)	12 (19)	33 (52)	5 (8)
Increased inpatient rotations	7 (11)	5 (8)	50 (79)	1 (2)
Decreased research blocks	5 (8)	3 (5)	53 (84)	2 (3)
Eliminated rotations	4 (6)	4 (6)	51 (81)	4 (6)
Increased non-neurological residents	4 (6)	0 (0)	56 (89)	3 (5)
Residency program external response ^c				
Applied to ACGME for additional residents	21 (33)	15 (24)	27 (43)	NA
Neurology department response				
Hired mid-level practitioners ^d	20 (32)	10 (16)	33 (52)	0 (0)
Hired neurohospitalists	9 (14)	6 (10)	48 (76)	0 (0)
Hired other faculty/attending neurologists	8 (13)	10 (16)	44 (70)	1 (2)
Hired moonlighting physicians	6 (10)	1 (2)	56 (89)	0 (0)
Hired additional nurses	3 (5)	4 (6)	55 (87)	1 (2)

Abbreviations: ACGME, Accreditation Council on Graduate Medical Education; NA, option was not available on survey.

^a N = 63.

^b Other specified residency program changes implemented not classified above includes rescheduling clinics (n = 1) and improved handoffs (n = 1).

^c Respondents were queried on applications within 2 years prior to the survey or plans within the following year.

^d Mid-level practitioners include physician assistants and nurse practitioners.

as indicated by FREIDA were assessed using Fisher exact test. Differences between respondents from departments or programs that instituted night float, increased faculty responsibility, and applied for additional residents compared to those that did not were evaluated across self-reported characteristics (postgraduate year 2 [PGY-2] class size, department FTE faculty size, and neurological science bed size) using the Wilcoxon Mann-Whitney test. For questions on program and department responses and frequency of faculty responsibilities, where multiple options could be selected, we used McNemar exact test to determine differences in the marginal frequency of selections. Multipoint scales were dichotomized appropriately for McNemar test. All tests were conducted at the 2-sided significance level of 5% using STATA software, version 12.0 (StataCorp, College Station, Texas).

Results

Respondents

In all, 123 ACGME-accredited neurology departments were surveyed and 63 responded (51% response rate). Responses were received from department chairs (23%), residency program directors (75%), or department administrator for 1 department (supplementary Table 1). Within their institutions' primary hospital, 71% of respondents reported ≥ 500 patient beds, with a mean of 44 neuroscience beds. In all, 84% (n = 53) of respondents were university affiliated, and the average PGY-2 class size was 5.6 residents (standard deviation = 2.7;

median = 5). The most frequently cited sources of funding for residency programs were Medicare (81%) and hospital funding (76%). No difference was detected in the size of metropolitan area ($P = .613$), residency program type ($P = .371$), or resident class size ($P = .088$; mean of 4.6 vs 5.7) for respondents compared to nonrespondents.

Residency Program Changes

Of the 63 responding residency programs, 50 (79%) implemented at least 1 programmatic change in direct response to the new duty hour requirements and an additional 6 programs planned at least 1 change within the next year (Table 2); 34 (54%) programs made more than one change, and of those that have already implemented a change, 19 have plans to make at least 1 additional change.

As seen in Table 2, the most common direct responses to the new requirements were the introduction of night float (n = 31; 49%) and increased faculty responsibility/coverage (n = 26; 41%). The most frequently planned response was the development of computer-based resources for resident education (n = 12; 19%), which an additional 21% (n = 13) of programs had already implemented. When asked regarding formal training of residents on the provision of sign-out, our study finds over 40% of responding programs do not provide training.

In all, 21 programs reported applying to ACGME within the previous 2 years for an average increase of 2 residents, and

Figure 1. Activities previously performed by residents, now performed by faculty neurologists to assist programs with 2011 duty hour requirement adherence. Leading patient family meetings were significantly selected more often than other choices ($P < .05$). Statistical test for significance was performed with dichotomized results combining “always” and “frequently” compared to “occasionally” and “never” using the McNemar 2-tailed exact test.

another 15 programs planned to apply in the next year for an average of 3 residents. Of those that applied, 17 (81%) programs reported approval of their request, while 2 programs reported that their application was still under consideration. The most common funding source for increases in approved residents trained was from within the institution ($n = 16$ departments; hospital, department, or school of medicine). Overall, 40 additional residents were approved; 29 were funded solely by institutional funds, 10 through combined institutional and federal funds (eg, Medicare, Medicaid, and Veterans Affairs), and 1 resident by federal funds alone.

Neurology Department Changes

In the past year, 26 departments hired 80 new providers accounting for 64 FTEs in direct response to the new ACGME duty hour requirements. Our respondents indicate these hires represent 33% of all new employees in the previous year (64 of 195 FTEs). The most common hires made or planned for by neurology departments in direct response to the new duty hour requirements were mid-level practitioners ($n = 20$ departments; 32%; $P < .01$; Table 2).

In addition, a variety of activities previously performed by residents are frequently covered by faculty neurologists to

assist with adherence to the new duty hour requirements within academic departments (Figure 1).

Cost Estimation

Based on residency program and department survey responses to those changes already implemented and assumptions made using publically available resources (Table 3), the 2011 ACGME guidelines cost responding departments \$12.7 million (in 2012 US dollars) or \$201 000 per department on average (Table 4). An additional analysis that included a projection of planned changes totaled \$22.7 million or an average of \$360 000 per department.

These costs were largely driven by hiring of mid-level practitioners, costing approximately \$64 000 per department or one-third of the estimated costs. The cost of all other new hires combined was, on average, \$85 000 per department. Approximately 20% of costs were on additional residents and 4% on computer-based resources.

In sensitivity analysis varying the assumptions across a range of reasonable values, the lowest cost scenario estimated that the requirements cost \$151 000 per department, and the highest cost scenario was over \$289 000 per department. When accounting for the adoption of changes planned for

Table 3. Financial Model Inputs and Assumptions to Estimate the Cost of the 2011 ACGME Resident Duty Hour Guidelines to Neurology Departments and Residency Programs.

Model Inputs	Implemented Changes	Projections of Planned Changes ^a	Assumptions	Sensitivity Analysis	Source
	No. of Units Employed, Survey Response Inputs		Annual Cost (2012 USD)	Range	
Substitute provider costs					
Registered nurse	3	4	65 478	53 664-78 707	US Bureau of Labor Statistics ⁹
Midlevel provider ^b	43	21	90 449	78 530-107 546	US Bureau of Labor Statistics ^{8,10}
Academic neurologist ^c	26	24	141 000	120 000-201 000	AAMC ¹²
Moonlighting physician ^d	8	1	211 500	180 000-301 500	Calculation
Employee ratio of benefits to salary			0.30	0.25-0.35	US Bureau of Labor Statistics ¹³
Adjustment for No. of FTEs per hire			0.80	0.70-0.90	Survey response ^e
Computer-based resource costs					
Computer-based resources ^f	13	12	40 000	10 000-60 000	Nuckols and Escarce, 2012 ³
Additional resident direct costs					
ACGME approved additional residents ^g	29	37	52 407	50 425-55 572	AAMC ¹¹
Resident ratio of benefits to stipend			0.28	0.23-0.35	AAMC ¹¹
Cost of overhead and teaching physicians per resident			42 540	36 463-48 617	Zeidel et al, 2005 ¹⁴

Abbreviations: ACGME, Accreditation Council on Graduate Medical Education; USD, United States Dollars; AAMC, American Association of Medical Colleges; FTE, full-time equivalents.

^a Projections of planned changes for substitute providers were obtained by multiplying the number of departments planning to hire an individual provider and the average departmental hiring rate among those departments having implemented the change. Plans for computer-based resource deployment and additional residents were taken directly from the survey.

^b Annual cost of mid-level providers is the average of that for nurse practitioners and physician assistants.

^c We assume new faculties were hired at the instructor level based on Departmental Salary Statistics Report for all schools and all regions, 2011-2012.

^d Moonlighting physicians were assumed to earn 1.5 times the annual earnings of an academic neurologist. This is approximately equivalent to 100 per hour over 12-hour shifts working half of a full year. Benefits were not applied to moonlighting physicians.

^e We assumed 0.80 FTEs for each new employee hired based on survey responses to questions regarding full time equivalents.

^f The cost of purchasing or developing computerized handover systems was assumed to be that for moderate sized institutions under the base case scenario with sensitivity to costs for small and large institutions.

^g Number of approved residents includes only those funded solely by institutional funds. Those additional residents funded by federal or external sources and those with combined sources of funding were excluded from the analysis.

Table 4. Estimated costs of 2011 ACGME resident duty hour guidelines to neurology departments and residency programs.

Model Outputs	Cost to Neurology Departments; n = 63 (thousands of 2012 USD)		Cost per Neurology Department (thousands of 2012 USD)	
	Base case	(Lowest to Highest)	Base case	(Lowest to Highest)
Implemented Changes				
Cost of substitute providers	9 415	(6 834-14 426)	149	(108-229)
Cost of computer-based resources	520	(130-780)	8	(2-12)
Cost of additional residents	2 753	(2 520-3 021)	44	(40-48)
Total Costs	12 689	(9 483-18 228)	201	(151-289)
Implemented Changes with Projections of Planned Changes ^a				
Cost of substitute providers	15 403	(11 954-22 433)	244	(190-356)
Cost of computer-based resources	1 040	(260-1 560)	17	(4-25)
Cost of additional residents	6 267	(5 735-6 876)	99	(91-109)
Total Costs	22 709	(17 949-30 869)	360	(285-490)

Abbreviations: ACGME, Accreditation Council on Graduate Medical Education; USD, United States Dollars.

^a Combined costs for changes already implemented by departments and projections of planned changes based on survey response.

by departments, costs were projected to reach between \$285 000 and \$490 000 per department.

Discussion

Neurology departments across the country have responded to the 2011 ACGME requirements by developing night float systems, investing in computer-based resources for resident education, and transferring work to more expensive labor. The average investment by each department to date likely exceeds \$200 000, or the approximate cost of a full-time neurologist, and may approach \$400 000 as planned changes are implemented. As the majority of these costs will recur annually (eg, cost of substitute labor and additional residents), total expenses for the average neurology department may reach over \$1 million by 5 years.

To date, there have been mixed perceptions across a variety of specialties on the effects of the 2011 ACGME requirements from both residents and program leadership,¹⁶⁻¹⁸ although few have focused on costs.³ Previous estimates of the cost to replace PGY-2 and above resident labor for all specialties within a single major teaching hospital as a result of the new duty hour guidelines were more than \$600 000 annually.³ Considering that neurology residents account for approximately 2% to 3% of residents nationally,¹⁹ prior estimates may be low. Based on our findings within neurology departments, costs to a single major teaching hospital may be on the order of \$6 to \$10 million per year.

One-third of all FTE hires by responding departments have been in direct response to the duty hour requirements at an estimated cost of over \$9 million to these departments and hospitals collectively, accounting for nearly 75% of the total costs in our study. These findings suggest an increasing demand for a nonresident workforce that comes at a substantial cost to departments. The most frequently substituted labor by departments was mid-level providers rather than neurohospitalists or other neurologists, consistent with the experience in pediatrics.²⁰ Mid-level providers have frequently been cited as a means to replace lost resident labor,^{20,21-25} which may cost hospitals nearly twice that of resident physicians.^{8,10,11} Although the clinical value of residents compared to mid-level providers remains unknown in neurology, comparisons in emergency medicine and primary care suggest similar clinical value.²⁶⁻²⁸

Our study explores some of the ways that departments and programs employ their new and existing faculty to assist with the loss of resident work, finding that faculties are frequently assisting residents in leading family meetings. This may have unintended consequences on the value of resident education. In addition, patient safety and quality of care, although not captured in this study, may be affected by the 2011 ACGME requirements. Our study focused primarily on changes that result in financial costs to departments and programs and further study may seek to justify these costs by examining the

effectiveness (or negative effects) on patient safety, quality of care, and resident education.

The majority of neurology residency funding is through Graduate Medical Education from the Centers for Medicare & Medicaid Services (supplementary Table 1); however, according to our survey, many of the neurology programs submitting applications for residency expansion are utilizing hospital funds for additional residency positions. At least 29 of the 40 new resident positions accepted by the ACGME are funded solely through institutional funds (ie, hospital, department, or school of medicine funds). The ACGME requires educational rationale to justify the addition of residents to neurology programs, and, therefore, an increase in the number of positions may not be granted on the basis of service requirements alone.²⁹ Nonetheless, these findings suggest a willingness to pay on the part of teaching hospitals, apart from federal subsidies, for the clinical value generated by resident physicians,^{22,23} despite increased stress on department resources to further invest in training infrastructure.¹⁹

Our study finds that nearly 60% of departments train residents on sign-out, and 21% have implemented computerized resources for resident education with potentially more programs in the process of developing such measures. However, the costs of these resources are likely low in comparison to new hires and additional residents, which account for the majority of the financial burden of the new requirements.

Limitations

Our survey was limited to departments with adult neurology residency programs that responded. Although prior surveys of neurology residency program directors have reported higher response rates,³⁰ our true response rate is comparable to that of recent surveys.³¹ Response to the survey in itself may introduce some selection bias; however, there were no differences in metropolitan size, resident class size, or program type between respondents and nonrespondents, suggesting that differences expected due to teaching hospital size may be discounted. Recall bias likely played a role in some responses and, therefore, the base case results may under- or overestimate costs. To ameliorate this bias, respondents were offered the option of "do not know" to survey questions for which they may have had incomplete information to prevent under- or over-reporting. Reassuringly, only 3 options within 1 question had more than 5% of respondents, indicating they did not know (see Table 2). The motivation of the study was to evaluate department and program level changes and costs of these changes resulting from the new requirements, and department leadership was deemed most knowledgeable in this respect within presurvey focus groups; however, respondents included individuals with different positions across departments (ie, chair, program director, and administrator) and, therefore, may limit the reliability of the study.

The financial costs of the ACGME guidelines to departments are likely underestimated by the exclusion of

anticipated or planned changes, therefore, we included an analysis to project the costs of departments planning for change with the limitation that these are forecasts of future events. We asked respondents for hires due to the requirements in FTEs to estimate the direct costs of hires replacing labor lost from PGY-2 and above resident neurologists. However, this method of estimation is dependent upon the accuracy of the work capacity of those providers hired. Our cost estimation only accounts for computerized resources for resident education and does not take into consideration the variety of methods used to train neurology residents in sign-out, including resident-to-resident and lecture-based training, which may have additional costs. Despite these limitations, in conducting a lowest cost/highest cost sensitivity analysis varying the values for 10 model assumptions, we find costs continue to be high, ranging from approximately \$150 000 to \$290 000 per department annually and could reach \$400 000 or more if planned changes are enacted. Therefore, our study reasonably estimates the cost of adoption for neurology departments and residency programs of changes in response to the 2011 ACGME resident duty hour requirements using a query-informed financial model to obtain information on mixed provider labor substitution and computer-based resource deployment.

Conclusions

The 2011 ACGME duty hour requirements were implemented to improve resident fatigue and well-being, enhance educational activities, and improve patient care. Neurology residency programs and departments across the country have implemented a variety of programmatic and departmental changes to meet these requirements, including developing computer-based resources, hiring providers, and acquiring additional residents. These changes have been at a significant cost to neurology departments and residency programs and should be balanced with recent pressures on the federal budget and funding of graduate medical education.

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Authors' Notes

Mr George, Dr Probasco, Dr Dorsey, and Dr Venkatesan contributed to drafting and revising the manuscript. Mr George, Dr Probasco, and Dr Venkatesan contributed to study concept and design. Mr George

and Dr Probasco contributed to the acquisition, analysis and interpretation of the data. Mr George conducted the statistical analysis. Dr Dorsey and Dr Venkatesan contributed to study supervision and coordination.

Declaration of Conflicting Interests

The authors declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Dr Venkatesan is the Associate Program Director of the Johns Hopkins Neurology Residency Program.

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Supplemental Material

The online appendix and tables are available at <http://nhos.sagepub.com/supplemental>

References

1. Common Program Requirements. Chicago, IL: Accreditation Council for Graduate Medical Education; 2010. http://www.acgme.org/acwebsite/home/Common_Program_Requirements_07012011.pdf. Accessed September 10, 2011.
2. Ulmer C, Wolman DM, Johns MME. Resident Duty Hours: Enhancing Sleep, Supervision, and Safety. Washington, DC: National Academy of Sciences Institute of Medicine; 2009. <http://iom.edu/Reports/2008/Resident-Duty-Hours-Enhancing-Sleep-Supervision-and-Safety.aspx>. Accessed February 23, 2013.
3. Nuckols TK, Escarce JJ. Cost implications of ACGME's 2011 changes to resident duty hours and the training environment. *J Gen Intern Med*. 2012;27(2):241-249.
4. Nuckols TK, Bhattacharya J, Wolman DM, Ulmer C, Escarce JJ. Cost implications of reduced work hours and workloads for resident physicians. *N Engl J Med*. 2009;360(21):2202-2215.
5. Fellowship and Residency Electronic Interactive Database. Chicago, IL: American Medical Association; 2012. <https://freida.ama-assn.org/Freida/>. Accessed October 10, 2011.
6. List of ACGME Accredited Programs and Sponsoring Institutions. Chicago, IL: Accreditation Council for Graduate Medical Education; 2012. <http://www.acgme.org/adspublic/>. Accessed January 25, 2012.
7. Probasco JC, George BP, Dorsey ER, Venkatesan A. Neurohospitalists: perceived need and training requirements in academic neurology. *Neurohospitalist*. In Press.
8. Occupational Employment and Wages. 29-1171 Nurse Practitioners. Washington, DC: US Department of Labor Bureau of Labor Statistics; May 2012. <http://www.bls.gov/oes/current/oes291171.htm>. Accessed September 13, 2013.
9. Occupational Employment and Wages. 29-1141 Registered Nurses. Washington, DC: US Department of Labor Bureau of Labor Statistics; May 2012. <http://www.bls.gov/oes/current/oes291141.htm>. Accessed September 13, 2013.
10. Occupational Employment and Wages. 29-1071 Physician Assistants. Washington, DC: US Department of Labor Bureau

- of Labor Statistics; May 2012. <http://www.bls.gov/oes/current/oes291071.htm>. Accessed September 13, 2013.
11. Survey of Resident/Fellow Stipends and Benefits. Washington, DC: Association of American Medical Colleges; October 2012. https://http://www.aamc.org/download/312786/data/2012stipend_surveyreportfinal.pdf. Accessed February 23, 2013.
 12. Report on Medical School Faculty Salaries 2011-2012. Washington, DC: Association of American Medical Colleges. <https://www.aamc.org/data/>. Accessed September 13, 2013.
 13. Employer Costs for Employee Compensation. Washington, DC: Department of Labor Bureau of Labor Statistics; September 2012. http://www.bls.gov/news.release/archives/eccec_12112012.htm. Accessed February 23, 2013.
 14. Zeidel ML, Kroboth F, McDermot S, et al. Estimating the cost to departments of medicine of training residents and fellows: a collaborative analysis. *Am J Med*. 2005;118(5):557-564.
 15. Consumer Price Index—All Urban Consumers. US Department of Labor Bureau of Labor Statistics. <http://data.bls.gov/cgi-bin/surveymost?cu>. Accessed September 13, 2013.
 16. Drolet BC, Christopher DA, Fischer SA. Residents' response to duty-hour regulations—a follow-up national survey. *N Engl J Med*. 2012;366(24):e35.
 17. Feig BA, Hasso AN. ACGME 2011 duty-hour guidelines: consequences expected by radiology residency directors and chief residents. *J Am Coll Radiol*. 2012;9(11):820-827.
 18. Lo V, Ward C. 2011 ACGME duty hour week proposal—a national survey of family medicine residents. *Fam Med*. 2011;43(5):318-324.
 19. Area Resource Files. US Department of Health and Human Services; 2010. <http://arfh.hrsa.gov/download.htm>. Accessed August 28, 2013.
 20. Freed GL, Dunham KM, Moran LM, Spera L. Resident work hour changes in children's hospitals: impact on staffing patterns and workforce needs. *Pediatrics*. 2012;130(4):700-704.
 21. Russell JC, Kaplowe J, Heinrich J. One hospital's successful 20-year experience with physician assistants in graduate medical education. *Acad Med*. 1999;74(6):641-645.
 22. Dorsey ER, Nicholson S, Frist WH. Commentary: improving the supply and distribution of primary care physicians. *Acad Med*. 2011;86(5):541-543.
 23. Iglehart JK. Medicare, graduate medical education, and new policy directions. *N Engl J Med*. 2008;359(6):643-650.
 24. Knickman JR, Lipkin M Jr, Finkler SA, Thompson WG, Kiel J. The potential for using non-physicians to compensate for the reduced availability of residents. *Acad Med*. 1992;67(7):429-438.
 25. Freiburg C, James T, Ashikaga T, Moalem J, Cherr G. Strategies to accommodate resident work-hour restrictions: impact on surgical education. *J Surg Educ*. 2011;68(5):387-392.
 26. Hamden K, Jeanmonod D, Gualtieri D, Jeanmonod R. Comparison of resident and mid-level provider productivity in a high-acuity emergency department setting [published online January 29, 2013]. *Emerg Med J*. 2013.
 27. Jeanmonod R, Delcollo J, Jeanmonod D, Dombchewsky O, Reiter M. Comparison of resident and mid-level provider productivity and patient satisfaction in an emergency department fast track. *Emerg Med J*. 2013;30(1):e12.
 28. Federman DG, Krishnamurthy R, Kancir S, Goulet J, Justice A. Relationship between provider type and the attainment of treatment goals in primary care. *Am J Manag Care*. 2005;11(9):561-566.
 29. Specialty-specific References for DIOs: Resident Complement Change. ACGME. http://acgme.org/acgmeweb/Portals/0/DIO_Resident_Complement_Change.pdf. Accessed November 9, 2013.
 30. Schuh LA, Adair JC, Drogan O, Kissela BM, Morgenlander JC, Corboy JR. Education research: neurology residency training in the new millennium. *Neurology*. 2009;72(4):e15-e20.
 31. Watson JC. Impact of the ACGME work hour requirements: a neurology resident and program director survey. *Neurology*. 2005;64(2):E11-E15.